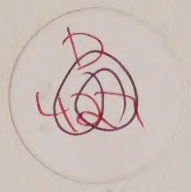
5-A-133



KEITHLEY IN

INSTRUCTION MANUAL

MODELS 412, 412C

LOGARITHMIC
MICRO-MICROAMMETERS

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the Cleveland factory, DDD 216-248-0400. You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

Keithley Instruments maintains a complete repair service and standards laboratory in Cleveland, and has an authorized field repair facility in Los Angeles and in all countries outside the United States having Keithley field representatives.

To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

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SECTION I INTRODUCTION

The Keithley Model 412 micro-microammeter is a line operated vacuum tube electrometer with a logarithmic meter scale which covers the range 10^{-7} to 10^{-13} ampere without range switching.

The features include full-scale voltage drop at the input of less than five millivolts, zero drift of less than .05 decade in 24 hours, good accuracy, built-in calibration standards and large output voltage. The output is sufficient to drive 1 and 5 milli-ampere recorders as well as the numerous potentiometer-rebalance recorders. In nuclear work, period circuits can be operated directly from the output without additional amplification. One output terminal is at ground, making it convenient to connect cathode ray oscilloscopes or pen-driving amplifiers, similar to Brush and Sanborn equipment.

The major panel controls are the OPERATE-CALIBRATE switch and the SET 10^{-11} control which establishes a reference point on the logarithmic scale. Minor controls are the RECOVER button, ZERO BAL adjustment, SET 10^{-8} adjustment, and the ON-OFF switch. The meter dial is illuminated and serves as the pilot light.

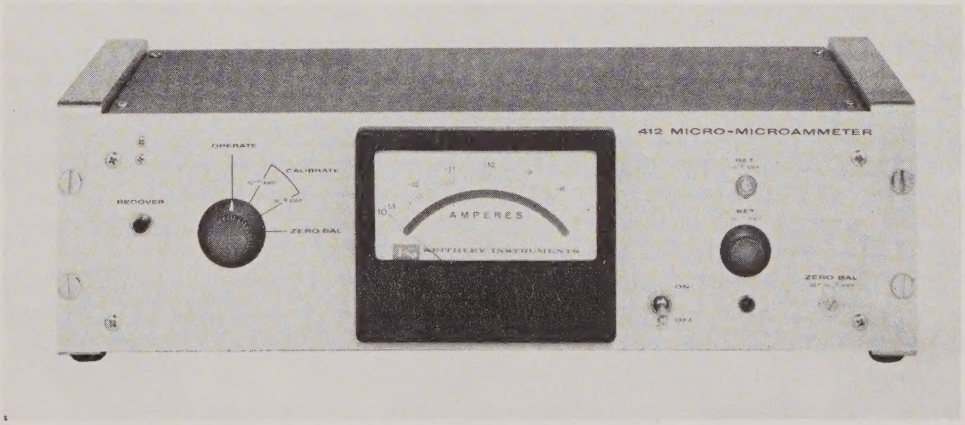


FIGURE 1. Keithley Instruments Model 412 Micro-microammeter with End Frames.

SPECIFICATIONS:

RANGE: 10^{-13} to 10^{-7} ampere on single log scale; positive currents only.

ACCURACY: $\pm$0.2 decade with source voltages greater than 1 volt.

ZERO DRIFT: Less than 0.05 decade in 24 hours after a 1-hour warm-up and with source voltages greater than 1 volt.

GRID CURRENT: Less than 5×10^{-14} ampere.

INPUT VOLTAGE DROP: Less than 5 millivolts for full-scale meter deflection on any range when properly zeroed.

EFFECTIVE INPUT RESISTANCE: 5×10^{4} at 10^{-7} ampere, increasing to 5×10^{10} at 10^{-13} ampere.

RISE TIME, MAXIMUM: Seconds, from 10% to 90%.

Current Change, amperes	No External Capacitance	With 5000 Picofarads Across Input
10^{-13} to 10^{-12}	3	6
10^{-12} to 10^{-7}	less than 1	less than 2

RECORDER OUTPUT: Zero at 10^{-13} ampere, increasing -1 volt per decade to -6 volts at 10^{-7} ampere, at up to 5 milliamperes. Noise less than 1% rms of full scale.

POLARIZING POTENTIAL: +216 volts for ion chambers, furnished on back of chassis.

CALIBRATION: Internal current source for 2-point calibration using front panel controls.

CONNECTORS: Input: uhf type. Output: Amphenol 80-PC2F. +216 volts: Amphenol 80C.

POWER: 105-125 volts, 60 cps, 25 watts. 50-cps and 210-250 volt models available.

DIMENSIONS, WEIGHT: 5-1/4 inches high x 19 inches wide x 9-3/4 inches deep; net weight, 18 pounds.

ACCESSORIES SUPPLIED: Mating input and output connectors.

SECTION II DESCRIPTION

The current range covered is 10^{-7} to 10^{-13} ampere and is displayed on a six inch panel meter for maximum readability. Accuracy is within plus or minus 0.2 decade and the output voltage is one volt per decade plus or minus 20%. Positive currents can be accepted and the output voltage is in the negative direction.

Standardization of the 412 is accomplished by turning the OPERATE-CALIBRATE switch to the 10^{-11} position and setting the meter at 10^{-11} by means of the SET 10^{-11} control knob. The calibration signal is supplied by means of a mercury battery and a 10^{11} ohm, 2% resistor.

Calibration of the 412 may be checked by advancing the OPERATE-CALIBRATE switch to 10^{-8} ampere after standardization has been accomplished as above. Adjustment may be made if necessary by means of a front panel screw-driver control labeled SET 10^{-8} AMP.

Amplifier balance may be finally checked by then advancing the OPERATE-CALIBRATE switch to ZERO BAL and checking to see if the meter needle goes to 10^{-13}. If necessary, a front panel control labeled ZERO BAL may be used to adjust this setting.

In general only the SET 10^{-11} control is routinely used. The other adjustments will require infrequent adjustment.

Input impedance is minimized by negative feedback. The voltage drop across the input terminals will be less than five millivolts for any position across the meter scale provided that the amplifier balance is properly set.

Grid current is less than 5×10^{-14} ampere and will not affect operation of the instrument.

Input switch labeled RECOVER is located at left side of the panel. Its purpose is to short out the feedback diode and allow quick dissipation of spurious charges which sometimes accumulate on the input of a micro-microammeter, or are caused by overloading the input.

Drift. After one hour warm up if the instrument is set on 1×10^{-11} ampere, the reading will not increase to greater than 1.1×10^{-11} ampere nor decrease to less than 9×10^{-12} ampere in the following eight hours of operation.

Output is provided for driving recorders. The amplifier will develop 6 volts for full-scale meter deflection, and 5 milliamperes can be drawn without upsetting the circuits. Connection can be made to the OUTPUT connector at the rear of the chassis. The connection details and suitable output attenuators are discussed in OPERATION, Section III.

Response Speed of the 412 depends upon the current and also upon the capacitance of the external circuitry. Because of the method of application of the negative feedback, the slowing effects of capacitance from the high input terminal to ground have been greatly reduced, but are still significant. Table I below gives typical response speeds; viz; the time of 90% response to a step function.

TABLE I

RISE TIME - to 90% of final current

Current change, amperes	With no significant external capacitance	With 5000 mmf across input
from 10^{-13} to 10^{-12}	less than 3 seconds	less than 6 seconds
from 10^{-12} to 10^{-7}	less than 1 second	less than 2 seconds

If averaging of statistical fluctuations at low currents is desired, a polystyrene capacitor may be placed across the feedback diode. The exact value will depend upon the response desired for the particular application but usually will be in the range of 5 to 50 micro-microfarads.

Amplifier Noise is principally power frequency, and is 60 millivolts rms max. at the output terminals, irrespective of the current range. From the most general point of view, grid current and amplifier zero drift are also background noise; these have already been discussed.

Circuit Description. A logarithmic scale is obtained by negative feedback from output to input with a diode whose emission is limited by negative plate cathode voltages. The diode used is the grid-filament structure of a type 5886 electrometer tube.

The 5886 offers outstanding advantages in this application:

(1) The insulation of the grid is of a very high order since the 5886 is an electrometer tube. Therefore the diode plate has very little leakage which would cause erratic effects in the low current region.

(2) The grid and filament in this tube are extremely small, so that capacity across the diode is minimal. This results in a considerable improvement in response speed over instruments which employ more conventional diodes.

The diode used for feedback is V8, type 5886. The grid is used as the diode anode and the filament as the cathode. R105 is placed in series with the grid to protect the tube.

R107 is 200 ohm, ten-turn potentiometer in series with R106 which provide a voltage drop of 2.5 volts. The feedback from the output is connected at this point so that variation of R107 will control the potential in series with the output. This potential is necessary to buck out the

voltage across the diode in order that the output can be kept at ground potential when the input is at ground potential.

The calibration circuit consists of a mercury battery, BA 1 (RM401R), and resistors R101, R102, R103 and R104. The OPERATE-CALIBRATE switch is used to select the desired signal, either 10^{-11} or 10^{-8} ampere. In the ZERO BAL position the diode is shorted out. In this condition the logarithmic characteristic of the amplifier is removed and the circuit is simply a linear feedback amplifier whose zero corresponds to the 10^{-13} position on the meter. The AMPLIFIER BAL screw-driver potentiometer adjusts the amplifier zero. With proper balance of the amplifier, there will be negligible dc voltage at the input of the Model 412 in normal operation.

Calibration. The meter calibration is established by alternating between the 10^{-11} and 10^{-8} positions of the OPERATE-CALIBRATE switch, which causes 10^{-11} and 10^{-8} ampere to flow in the input of the Model 412. The corresponding potentiometers are adjusted until these calibration signals read properly on the meter. The 10^{-11} SET control adjusts the buck-out voltage in series with the diode and thus sets the static resistance of the diode at one point, while the 10^{-8} SET controls the gain of the amplifier and thus adjusts the change of the diode voltage with current, so that the rest of the scale reads correctly. Once these adjustments are made only the SET 10^{-11} control needs to be used to compensate for drift. The other controls will require infrequent adjustment.

The RECOVER switch shorts out the diode and allows the circuit to recover from large overloads quickly.

All plate and filament supplies are regulated by a Sola resonant transformer. Conventional half-wave rectifier filter circuits supply the B+ and B- potentials.

SECTION III OPERATION

Connect the input to the current source and the output to the recorder of external indicator if desired.

Plug the power cord into a 117 volt 60 cps outlet. Note that since a Sola resonant regulating transformer is used, the power frequency as well as the voltage must be of the proper value.

Turn OPERATE-CALIBRATE switch to 10^{-11} ampere.

Turn on power switch.

After about 15 minutes warm-up set meter to 10^{-11} with SET 10^{-11} control.

Check calibration by advancing OPERATE-CALIBRATE switch to 10^{-8} position. Adjust if necessary as discussed in Section II.

Check amplifier balance by advancing OPERATE-CALIBRATE switch to ZERO BAL. Adjust if necessary.

Recheck at 10^{-11} and readjust if necessary. Instrument is now ready to operate. Recheck occasionally for drift by using 10^{-11} position on OPERATE-CALIBRATE switch and by adjusting with SET 10^{-11} control. The screwdriver adjustments should require infrequent attention.

Input, using cabling

The current source should be connected to the input connector with the high impedance side of the current source associated with central conductor of the connector. The lead-in cable should be polyethylene, polystyrene, or teflon insulated coaxial cable, and the connector should have teflon insulation. Amphenol type 83-756 or equivalent is recommended. During preparation of cable and connectors, it is essential that all high impedance surfaces be kept scrupulously clean to avoid leakage. With graphite coated cable, it is necessary to avoid tracking graphite onto the high impedance surfaces of the cut end of the insulation and the teflon surface of the connector. Movement of the cable during measurement should be avoided since this will cause spurious needle movements, because of capacitance changes and generation of static charges.

RECORDING: The Model 412 is provided with an output connector on the rear of the chassis for recording. The output for full-scale meter deflection is minus six volts. The maximum current that may be drawn from the output terminals is 5 milliamperes. This output is suitable for driving one and five milliampere recorders as well as recorders employing an amplifier. Amphenol 80PC2F is the chassis connector, Amphenol 80MC2M the mating plug. Terminal #1 is ground.

Table II gives resistance to be used in series with one and five milliampere recording milliammeters, to make the recorder full-scale deflection

equal the panel meter full-scale deflection.

TABLE II

Recorder	Series Resistance
1 m.a.	4K to 5K
5 m.a.	950 to 1250 ohms

The exact series resistance varies from recorder to recorder, and a portion of the series resistance should be a potentiometer so that the recorder may be calibrated exactly against the panel meter.

A suitable voltage divider for more sensitive recorders can easily be made, keeping in mind that 6 volts appear at the output terminals for full-scale deflection of the panel meter, and that a 1200 ohm divider will not draw too much output current and will be sufficiently low impedance to connect to amplifier inputs.

The Speed of Response, or the time constant of an input transducer and micro-microammeter, depends upon the speed of response of the circuitry of the instrument and also upon the capacitance of the current source and its connecting cable. Because of the way the negative feedback is applied in the Model 412, the external input capacitance is not nearly as important as in the older systems using a voltmeter across a shunting resistor or diode, and quite large capacitances can be tolerated without having an impossibly slow response. Thus, a cable run from an ion chamber to the micro-microammeter is permissible.

+216 Volts. A connector has been mounted on the back face of the chassis to provide +216 volts for polarizing an ion chamber. The potential is derived from OB2 regulators and is well filtered. The supply can be short circuited without damaging it. The chassis connector is Amphenol 80C, and 80M is the mating plug.

SECTION IV MAINTENANCE

The Keithley Model 412 Micro-microammeter has been designed to give long, trouble-free service. High quality components have been used throughout, and the circuits are stabilized by a substantial amount of negative feedback.

DR 11149-C, at the back, is the detailed circuit schematic diagram of the Model 412. The circuit operation was discussed in Section II, Description.

Vacuum tubes V1 and V2 are two electrometer tubes and are located in an aluminum can which plugs onto the top of the chassis near the input terminals. These tubes have been selected, matched and labelled; V1 is Keithley part EV5886-8 and V2 is EV5886-8. It is recommended that the complete input tube assembly, Model 4102 be kept on hand for replacement purposes.

Feedback diode V8 is a Keithley part EV5886-6 which is tested for the logarithmic characteristic. Use normal electrometer tube care in handling the 5886 so that the glass at the press will not become contaminated.

INSULATION: All insulation for the high impedance conductors is made of teflon, as are the contact insulators on the range switch. This should give satisfactory service in all humidities. Occasionally, the high impedance insulators should be inspected to insure that they are free from dirt and dust, and brushed off if necessary.

CONNECTOR CAP: The cap for the input connector should be kept in place whenever the connector is not being used. In storage and in transport, it keeps the insulation from accumulating dust, dirt and moisture. Before screwing the cap back onto the connector, be certain that it is clean, so the insulation will not be contaminated and so that a low impedance bridging conductor will not be formed between the high impedance contact and the grounded cap.

Reference Voltage Battery BA-1 should be replaced once yearly.

Circuit Desig.	Description	Part No.
BA-1	Battery, 1.34, Mallory RM401R	BA-8
C-101	1000 mfd. Electrolytic 12 V. Capacitor	C11-1000
C-102	.02 mfd. Disc 600 VDC Capacitor	C22-0.02
C-103	100 mmf. Disc 600 VDC Capacitor	C22-100
C-104	Same as C-103	
C-105	5 mmf. Polystyrene 200 DC Capacitor	C31-5
C-401	Capacitor, Electrolytic, 250 V. 40 mfd.	C27-40
C-402	Capacitor, Electrolytic, 150 V. 150 mfd.	C9-150
C-403	Same as C-401	
C-404	Dame as C-402	
C-405	Same as C-401	
C-406	Capacitor, Electrolytic, 450 V. 20 mfd.	C8-20
C-407	Same as C-102	
C-408	Capacitor, 1.0 mfd. Supplied with	TR-17
FU-1	Fuse, 1 $\frac{1}{2}$ ampere	FU-8
ME-1	Meter, 1 ma. 6" - illuminated	ME-8
R-101	34 K, Deposited Carbon, 1/3 w. 1% Resistor	R12-34K
R-102	100K, Deposited Carbon, 1/3 w. 1% Resistor	R12-100K
R-103	10^{11} Himeg Resistor	R20-10^{11}
R-104	10^{8} Deposited Carbon, 2 w. 1%	R14-100M
R-105	60K Deposited Carbon, 1/3 w. 1%	R12-60K

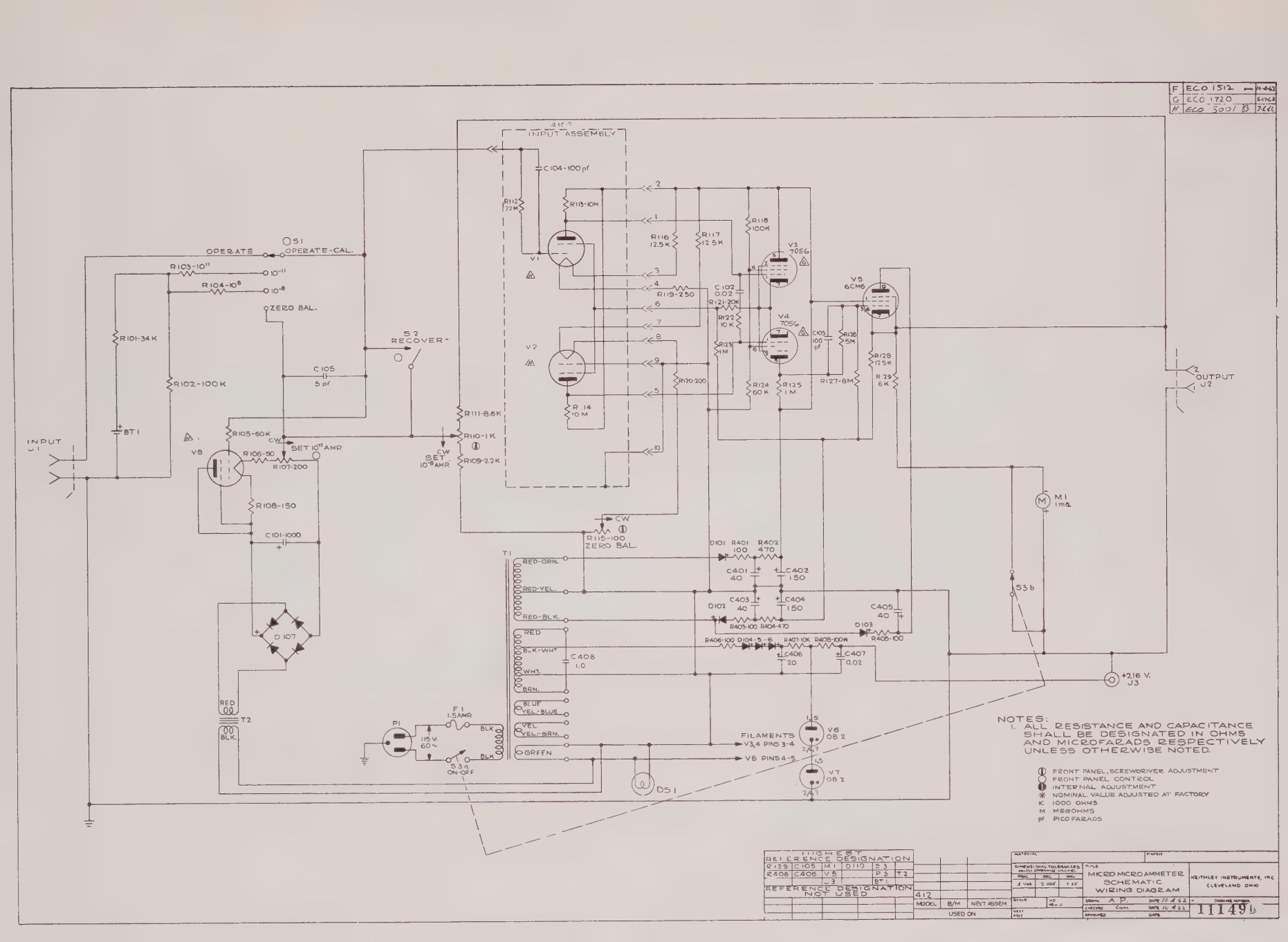
Circuit Design.	Description	Part No.
R-106	50 Deposited Carbon 1/3 w. 1% Resistor	R12-50
R-107	200 10 turn Potentiometer	RP4-200
R-108	150 Deposited Carbon 1/3 w. 1% Resistor	R12-150
R-109	2200 Deposited Carbon 1/3 w. 1% Resistor	R12-2200
R-110	1 K Potentiometer, w.w. 2 w. 10% Resistor	RP3-1000
R-111	8600 Deposited Carbon 1/3 w. 1% Resistor	R12-8600
R-112	22M Composition $\frac{1}{2}$ w. 10% Resistor	R1-22M
R-113	10M Deposited Carbon 1 w. 1/2% Resistor	R12-10M
R-114	Same as R-113	
R-115	100 w.w. 2 w. 10% Potentiometer	RP3-100
R-116	12.5K w.w. P.C. 7 w. 3% Resistor	R7-12.5K
R-117	Same as R-116	
R-118	Same as R-102	
R-119	250 w.w. $\frac{1}{4}$ w. 1% Resistor	R18-6-250
R-120	200 w.w. $\frac{1}{4}$ w. 1% Resistor	R18-6-200
R-121	20K Deposited Carbon 1/3 w. 1% Resistor	R12-20K
R-122	10K Composition $\frac{1}{2}$ w. 10% Resistor	R1-10K
R-123	1 M Deposited Carbon 1/3 w. 1% Resistor	R12-1M
R-124	Same as R-105	
R-125	Same as R-123	
R-126	5 M Deposited Carbon 1 w. 1% Resistor	R12-5M R13-5M
R-127	8 M Deposited Carbon 1 w. 1% Resistor	R13-8M
R-128	Same as R-116	
R-129	6 K Deposited Carbon 1/3 w. 1% Resistor	R12-6K

REPLACEABLE PARTS LIST - MODEL 412

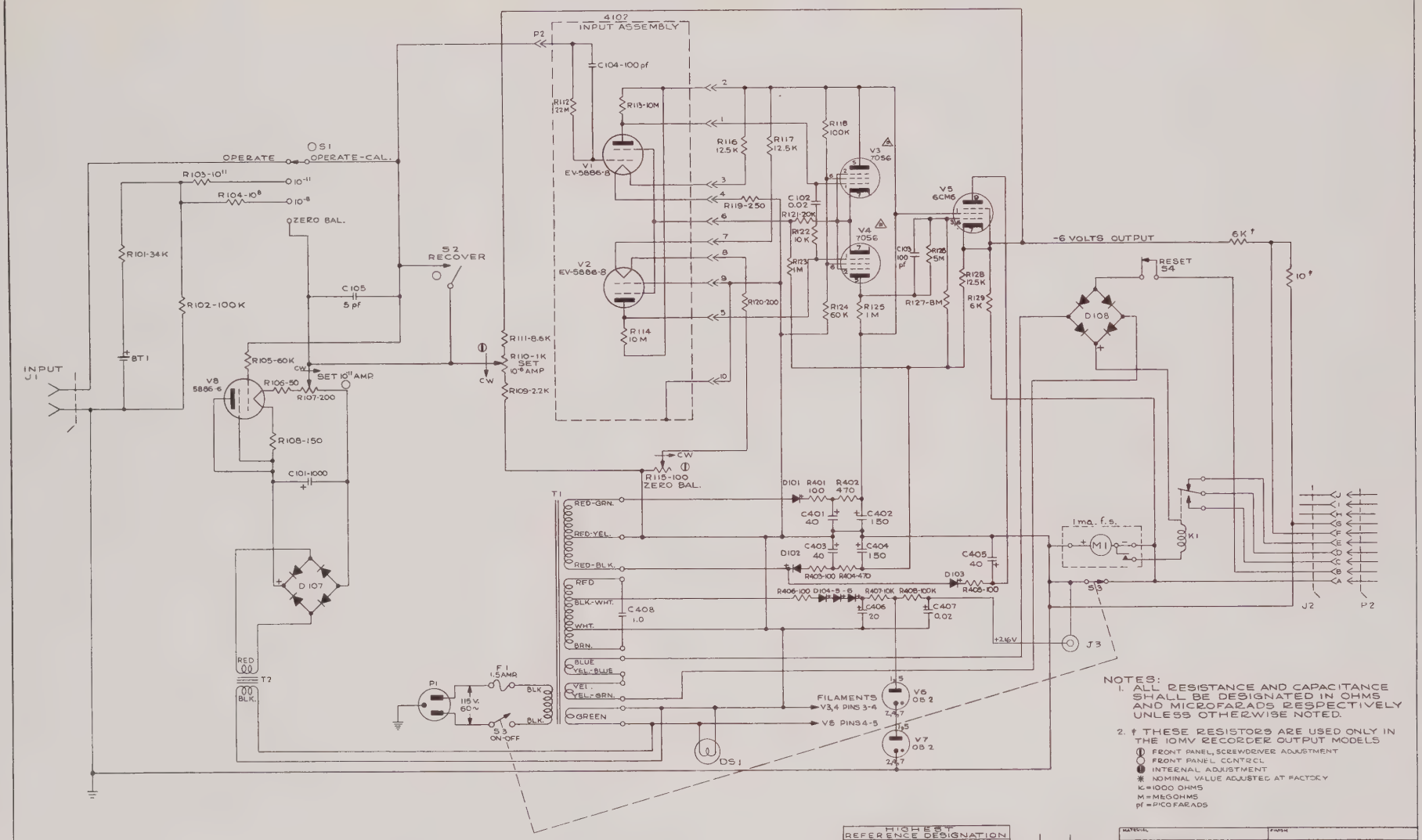
Circuit Desig.	Description	Part No.
R-401	100 Composition ½ w. 10% Resistor	R1-100
R-402	470 Composition ½ w. 10% Resistor	R1-470
R-403	100 Composition ½ w. 10% Resistor	R1-100
R-404	470 Composition ½ W. 10% Resistor	R1-470
R-405	100 Composition ½ w. 10% Resistor	R1-100
R-406	100 Composition ½ w. 10% Resistor	R1-100
R-407	10K Composition ½ w. 10% Resistor	R1-10K
R-408	100 K Composition ½ w. 10% Resistor	R1-100K
D101	Rectifier, Silicon, (Number 1N3255)	RF-17
D102	Rectifier, Silicon (Number 1N3255)	RF-17
D103	Rectifier, Silicon (Number 1N3255)	RF-17
D104	Rectifier, Silicon (Number 1N3255)	RF-17
D105	Rectifier, Silicon (Number 1N3255)	RF-17
D106	Rectifier, Silicon (Number 1N3255)	RF-17
D107	Rectifier, Selenium 30 ma	RF-6
S1	Switch, Function	SW-37-1
S2	Switch, Push Button -- Recover	
S3	Switch, Toggle - DPDT	SW-14
T-1	Transformer, Sola 71354	TR-17
T-2	Transformer, Central K1-106	TR-11

REPLACEABLE PARTS LIST - MODEL 412

Circuit Desig.	Description	Part No.
V-1	Tube - 5886	EV 5886- 8
V-2	Tube - 5886	EV 5886- 8
V-3	Tube - 6 CB 6	EV 6CB6
V-4	Tube - 6 CB 6	EV 6CB6
V-5	Tube - 6 CM 6	EV 6CM6
V-6	6627 - Tube	6627
V-7	6627 - Tube	6627
V-8	Tube - 5886	EV -5886 -5X


412
INPUT ASSEMBLY
INPUT
J1
BT1
S1
OPERATE
OPERATE-CAL.
R103-10^11
10^-11
R104-10^8
10^-8
ZERO BAL.
R101-34K
R102-100K
C105
5 pf
S2
RECOVER
R105-60K
CW
SET 10^11 AMP.
V8
R106-50
R107-200
R108-150
C101-1000
D107
RED
T2
BLK.
R111-8.6K
R110-1K
CW
SET 10^8 AMP.
R109-2.2K
C104-100 pf
R112 22M
R113-10M
V1
V2
R116 12.5K
R117 12.5K
R118 100K
V3 7056
C102 0.02
R121-20K
R119-250
R122 10K
R123 1M
V4 7056
R124 60K
R125 1M
R120-200
R 14 10M
V5 6CM6
C103 100 pf
R126 5M
R127-8M
R128 12.5K
R 29 6K
OUTPUT
J2
M1
1ma.
R115-100
ZERO BAL.
T1
RED-GRN.
RED-YEL.
RED-BLK.
RED
BLK-WHT
WHT.
BRN.
BLUE
YEL-BLUE
YEL
YEL-BRN.
GREEN
D101 R401 100 R402 470
C401 40
C402 150
C403 40
C404 150
D102
R403-100 R404-470
C405 40
D103
R405-100
R406-100 D104-5-6 R407 10K R408-100M
C406 20
C407 0.02
C408 1.0
+2.16 V.
J3
S3b
P1
F1
1.5AMP
115 V.
60~
S3a
ON-OFF
BLK
BLK
FILAMENTS
V3,4 PINS 3-4
V5 PINS 4-5
V6
OB 2
V7
OB 2
DS1
NOTES:
1. ALL RESISTANCE AND CAPACITANCE SHALL BE DESIGNATED IN OHMS AND MICROFARADS RESPECTIVELY UNLESS OTHERWISE NOTED.
FRONT PANEL, SCREWDRIVER ADJUSTMENT
FRONT PANEL CONTROL
INTERNAL ADJUSTMENT
NOMINAL VALUE ADJUSTED AT FACTORY
K 1000 OHMS
M MEGOHMS
pf PICO FARADS
F ECO 1512
G ECO 1720
H ECO 5001 B3
HIGHEST REFERENCE DESIGNATION
R129 C105 M1 D110 S3
R408 C408 V8 P3 T2
J3 BT1
REFERENCE DESIGNATION NOT USED
412
MODEL B/M NEXT ASSEM
USED ON
MATERIAL
FINISH
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
FRAC DEC ANG
2 PLACE ± .005 ± 1°
SCALE NO REV.
NEXT ASSY
TITLE
MICRO MICROAMMETER SCHEMATIC WIRING DIAGRAM
KEITHLEY INSTRUMENTS, INC CLEVELAND OHIO
DRAWN A.P. DATE 10-1-62
CHECKED DATE 10-4-62
APPROVED DATE
DRAWING NUMBER
111491

A	ECO 1512	10-4-62
B	ECO 1720	3-17-63



NOTES:
1. ALL RESISTANCE AND CAPACITANCE SHALL BE DESIGNATED IN OHMS AND MICROFARADS RESPECTIVELY UNLESS OTHERWISE NOTED.
2. † THESE RESISTORS ARE USED ONLY IN THE 10MV RECORDER OUTPUT MODELS

- ◐ FRONT PANEL, SCREWDRIVER ADJUSTMENT
- ○ FRONT PANEL CONTROL
- ◑ INTERNAL ADJUSTMENT
- ✱ NOMINAL VALUE ADJUSTED AT FACTORY

K = 1000 OHMS
M = MEGOHMS
pf = PICOFARADS

HIGHEST REFERENCE DESIGNATION					
C129	C105	M1	D114	S4	K1
R408	C408	V8		P3	T2
		J3		BT1	

REFERENCE DESIGNATION NOT USED

MODEL 412C B/M NEXT ASSEM

USED ON

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: FRAC ± 1/64, DEC .XX ± .005, DEC .XXX ± .130

TITLE: MICRO MICROAMMETER SCHEMATIC WIRING DIAGRAM

KEITHLEY INSTRUMENTS, INC. CLEVELAND OHIO

SCALE NO REV.-3

DRAWN A.P. DATE 10-4-62

CHECKED DATE 10-4-62

APPROVED DATE

DRAWING NUMBER 12723D

NEXT ASSY

REPAIR AND CALIBRATION FORM

For repair or calibration, please fill out this form and return it with your instrument to:

Sales Service Department
Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

R-
Do not write in this space.

User's Name _____ Telephone _____ Ext. _____
Company _____ Address _____
Division _____ City _____ State _____ Zip _____
Date _____ Model No. _____ Serial No. _____

1. Reason for Return
   - ☐ Repair and Recalibration
   - ☐ Recalibration only (No report, except as specified in item 4 on reverse)*

   *If repairs are necessary to meet specifications, they will be in addition to the calibration.

2. Calibration Report Desired
   - ☐ Report of Calibration Certified Traceable to N.B.S.
   - ☐ Calibration Report
   - ☐ Certificate of Compliance
   - ☐ None

   (for details, see reverse side of this form)

3. To help repair the instrument, briefly describe the problem: _____

4. Is the problem ☐ Constant ☐ Intermittant
   Under what conditions does the problem occur:
   a) Control setting _____
   b) Approx. Temperature _____ °F
   c) Approx. Temperature variation ± _____ °F
   d) Approx. Humidity (high, medium, low) _____
   e) Line voltage _____
   f) Other (such as line transients, line variations, etc.) _____

5. Please draw a block diagram of the system using the Keithley. List any other pertinent data which can help in the repair. Include charts or other data if available.
   Signal Source _____
   Source Impedance _____
   Readout Device:
   - ☐ Recorder
   - ☐ Oscilloscope
   - ☐ Other
   - ☐ None

   Lengths & Types of Connecting Cables _____

6. What repairs or modifications have been made on this instrument which are not on file with the Keithley Repair Department? _____

7. Please enclose any other pertinent data and charts which you feel might help the Repair and Calibration Department

_____ Signature _____ Title

1267

CALIBRATIONS AVAILABLE AT KEITHLEY INSTRUMENTS.

Listed and defined below are the four types of calibrations and their associated report formats which are presently available at Keithley Instruments. They fall into the following categories:

1. Report of Calibration Certified Traceable to the National Bureau of Standards
2. Calibration Report
3. Certificate of Compliance
4. Recalibration

All calibration and certification performed by Keithley Instruments is in accord with MIL-C-45662A.

Prices shown below are in addition to repair charges for any work necessary to place a customer's unit into first class condition prior to the calibration.

1. Report of Calibration Certified Traceable to the National Bureau of Standards.

   This is a completely documented report, including all basic errors or deviations from nominal settings on appropriate ranges, terminals, dials, etc. Work is performed using the primary standards of the company with secondary transfers kept to a minimum. The NBS test numbers for the latest recalibration of the primary standards are furnished.

   By definition, the above is performed in our Standards Laboratory so that random operator induced error is minimized and maximum protection to the equipment used is maintained.

   This type of calibration is not recommended for instruments with a basic inaccuracy of 1% or greater. The precision involved in this report makes it uneconomical for such instruments. The Calibration Report listed below (No. 2) would be better suited in this case.

   As of 12/1/67 the Report of Calibration Certified Traceable to the National Bureau of Standards is available on the following instruments at the prices listed:

Model 140	$325	Model 5155 (Complete Set)	$265
Model 260	$220	Model 5155-10^{8}	$ 45
Model 261	$280	Model 5155-10^{9}	$ 45
Model 515	$520	Model 5155-10^{10}	$ 45
Model 630	$250	Model 5155-10^{11}	$ 55
Model 660A	$200	Model 5155-10^{12}	$ 55
Model 662	$250	Model 5155-10^{13}	$ 75

2. Calibration Report.

   This report shows only the cardinal range, terminal, dial, etc. errors as determined by production calibration equipment and personnel. The production equipment is maintained traceable by transfer techniques against the primary standards maintained by the company. We attest to this fact and list basic deviations from nominal but the conditions of calibration are not as precisely controlled as the previous report nor are NBS test numbers supplied.

   This report is available for any instrument in our line. As of December 1, 1967, only the following price has been established for this report:

   Model 261 . . . . . $50

   Prices for other units can be estimated upon request.

3. Certificate of Compliance.

   This is merely a restatement of the basic guarantee that the instrument was calibrated on equipment that is maintained by our standards personnel against primary standards. No report is issued.

   This Certificate of Compliance is available at no charge for any instrument with the exception of the Model 261.

   A newly purchased Model 261 or one returned for repair or recalibration is automatically supplied with a Calibration Report (as described in (2) above). The nature of this instrument makes it necessary to complete this report to ascertain specified accuracy. This Calibration Report is forwarded to the customer with the instrument. The $50 charge is incorporated as part of the normal calibration charge of the Model 261.

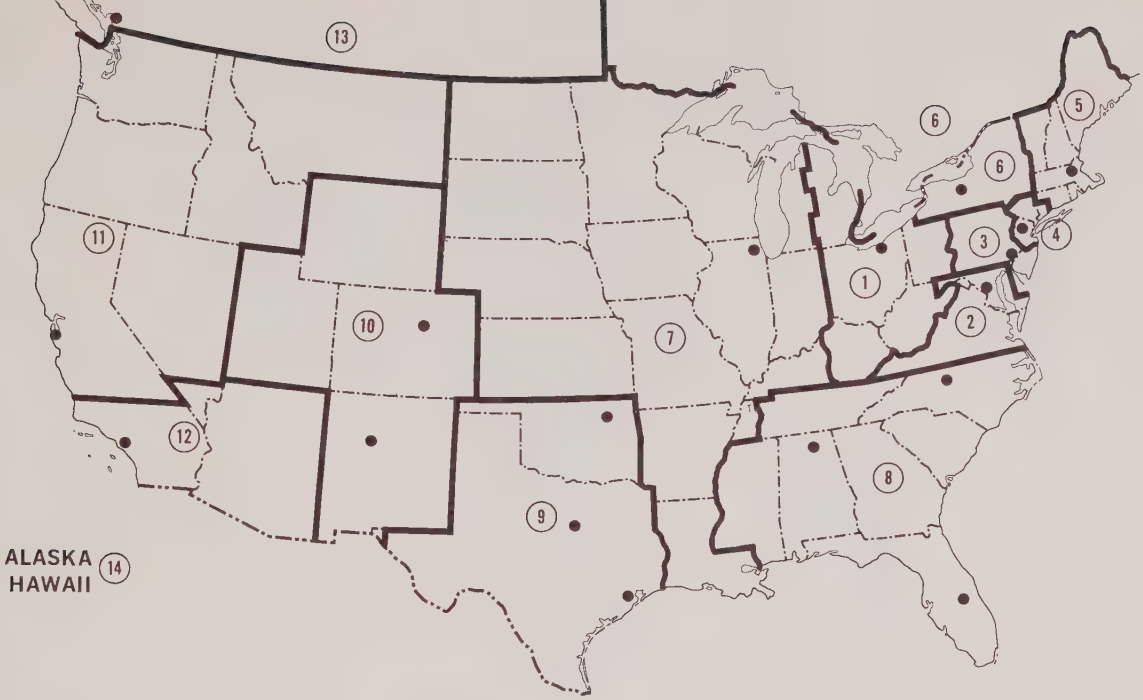
4. Recalibration.

   This is a recalibration of the instrument according to our factory calibration procedures. The prices for this as of December 1, 1967 are as follows:

   Model 260 . . . . . $75 (No report supplied. A Certificate of Compliance can be had at no charge if requested).

   Model 261 . . . . . $50 (Calibration Report as described in (2) above is supplied. See (3) for explanation).

   All other instruments are on a time and material basis for the particular unit involved.



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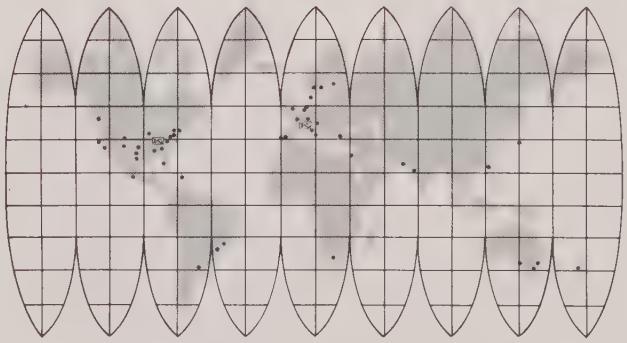

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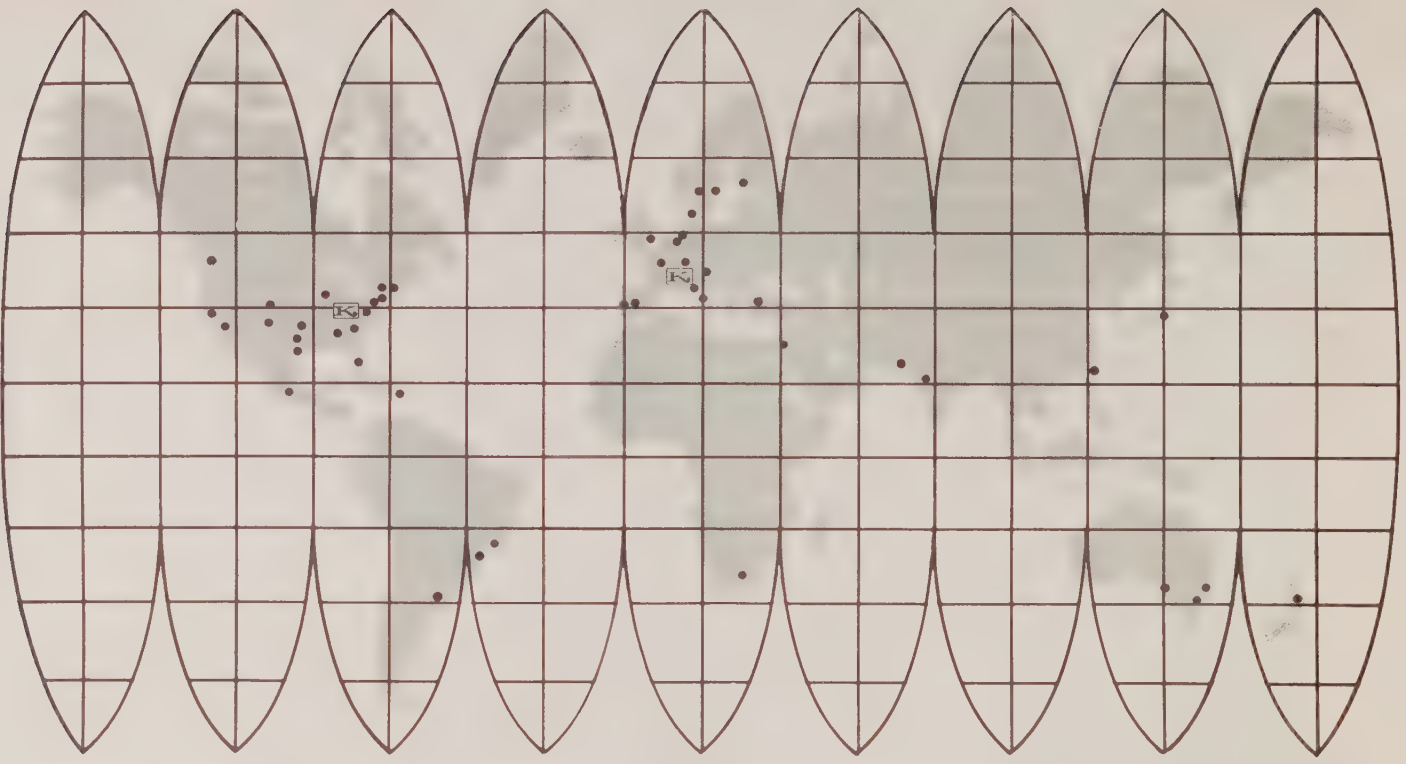

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CHANGE NOTICE

December 3, 1968

MODEL 412 MICRO-MICROAMMETER

Page 2-1, paragraph on drift. Change to the following:

After one hour warm up if the instrument is set on 1×10^{-11} ampere, the reading will not increase to greater the 1.05×10^{-11} ampere nor decrease to less than 9.95×10^{-12} ampere in the following eight hours of operation.

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